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Comparative study of structural variations in gill rakers of different marine and freshwater herbivore and carnivore fishes

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Abstract

Fish gills are comb like structure richly supplied with blood vessels. It is the site of gaseous exchange. It plays a vital role of not only respiration but also ionic balance, osmotic balance and filtration of food. Gill rakers are associated with gills. Fishes are herbivore, omnivore or carnivorous. They filter the suspended food particles. According to their feeding habit structure of gill rakers varies. Both marine and freshwater herbivore fish longest gill raker. In our experiment highest length at gill raker observed as 950 µm in silver carp and carnivore fishes contain small minute raker even sometimes it is absent. Smallest length of a gill raker observed in Topse (*Polynemus paradiseus*) is 150 µm.

Keywords: Gills, gill rakers, herbivore, carnivore

Introduction

Fishes are aquatic vertebrate, having opercular gills. Fish gills are vascularized and surrounded by epithelium which acts as a barrier between fish blood and environment. Fish gills are organ that allows aquatic respiration. Gases such as oxygen and carbon dioxide are exchanged using the gills that are protected under bony gill covers in Osteichthyes on both sides of the pharynx. These filaments have a wide range of function that includes the transfer of ions and water as well as exchange of oxygen, carbon dioxide, acids and ammonia. Each filament consists of a capillary network that provides a large surface area for exchange of oxygen and carbon dioxide. Rakers are long filamentous but carnivorous gill rakers are slow pointed, sharp structure. Gill raker is a comb like cartilaginous or bony structure present overlapping with each other within the pharyngeal cavity. Gill rakers are projections of gill arches, responsible for food collection and feeding habit. The main function of gill rakers is to save respiratory surfaces of gill filament from damage. The freshwater fishes maintain the salt balance by absorbing a specific measure of water through the membranes of gills and mouth. Due to water intake a large quantity of urine is produced, through which a large amount of salt is removed. The salt is replaced by mitochondrial rich cells of gills. The feeding habit of fish influences the morphology and its function of gill rakers. Generally, herbivores have a long, numerous, garnish gill rakers. In case of them the anterior gill rakers on 1st gill arch appears as a needle spine which helps them in feeding (Mousa *et al.*, 2016) [8]. In case of carnivores, gills are small and few in number. In them a spine present on lateral gill rakers of 1st gill arch, which prevent the escape of slippery, smooth prey. (Alsafy 2013) [3].

The shape of gill, their size and pattern of distribution varies in many species of fishes. According to structure gills are of following types

- Hemibranch gill:** A gill with lamellae or filaments in only one side is called hemibranch gill. It has a single layer of filaments.
- Holobranch gill:** A gill in which two rows of filaments are present on gill arch is called holobranch gill.

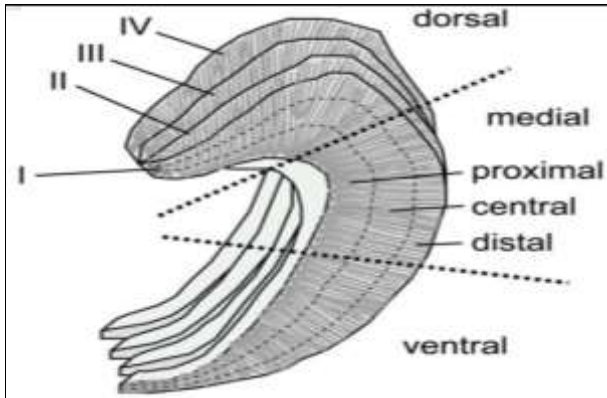


Fig 1: Hemibranch gill

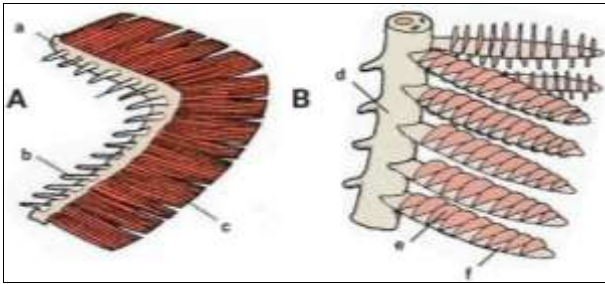


Fig 2: Holobranch gill

Gill morphology in Bony fish: In bony fishes' gills lie in a branchial chamber which is covered by a bony operculum. Majority of bony fishes have five pairs of gills.

Gill morphology in Cartilaginous fishes: Sharks and rays have five pairs of gills but the primitives' ones have six or seven pairs. Adjacent slits are separated by a cartilaginous gill arch which projects like a long sheet like septum, partly supported by another piece of cartilage called gill ray.

Gill rakers in fishes: The gill rakers are cartilaginous or bony structures that project to the inside of the pharyngeal cavity (Almeida *et al.*, 2013) [2]. The primary function of the gill raker is to guard the fragile respiratory surfaces of the gill filaments from potential damage by particulates within the water taken into the buccal cavity during respiration. (Langeland and Nost 1995) [7]. The gill raker serves as one of the most important food processing devices in fishes.

The current studies aim to distinguish between the morphology of gills between carnivorous and herbivorous fishes of fresh water. Our current study is based on these herbivorous fishes:

1. *Labeo rohita*, 2. *Catla catla*, 3. *Cirrihinus mrigala*, 4. *Puntius sarana*, 5. *Hypophthalmichthys molitrix*

And carnivorous fishes like

1. *Mystus sp.*, 2. *Glossogobius giuris*, 3. *Channa sp.*, 4. *Notopterus notopterus*

As well as we studied marine fishes also. The carnivorous fishes collected were

1. *Harpodon nehereus*, 2. *Pampus aregentus*, 3. *Lates calcarifer*, 4. *Polynemus paradiseus*, 5. *Coilia dussumieri*

The only marine herbivorous fish collected was- *Sardinella longiceps* (Indian oil Sardine)

Material and Methods

- Different carnivorous and herbivorous fishes both from as well as fresh and marine sources are brought from the

local fish market (Shyambazar, Kolkata market) to the postgraduate campus of Vidyasagar College, Salt Lake, Fish Biology and Aquaculture Lab.

- Dissection and staining:** Gills are dissected out from the branchial chamber with the help of a pair of scissors and forceps. Individual gills are vigorously washed with tap water to remove blood and mucous clay. Then gills are dehydrated through the graded alcohol, stained with Eosin, cleared with xylene, and mounted with DPX.
- Observation and measurement:** Observe the gill rakers under the compound light Motic B1 series microscope. The gill raker length is measured by micrometry process using stage micrometer and ocularometer.

Results and Discussion

Various types of modifications of gills are found in different fishes. Our current study is based on observation of gill and gill rakers of different herbivorous and carnivorous freshwater fishes as well as marine fishes.

In our study we found the medium-sized homogenous gill in *Labeo rohita*. Numerous gill filaments are found here. Two rows of gill filaments are present in each gill arch. Scientists Aung and Tun (2017) reported that gill raker is short and flat also of *Labeo rohita*.

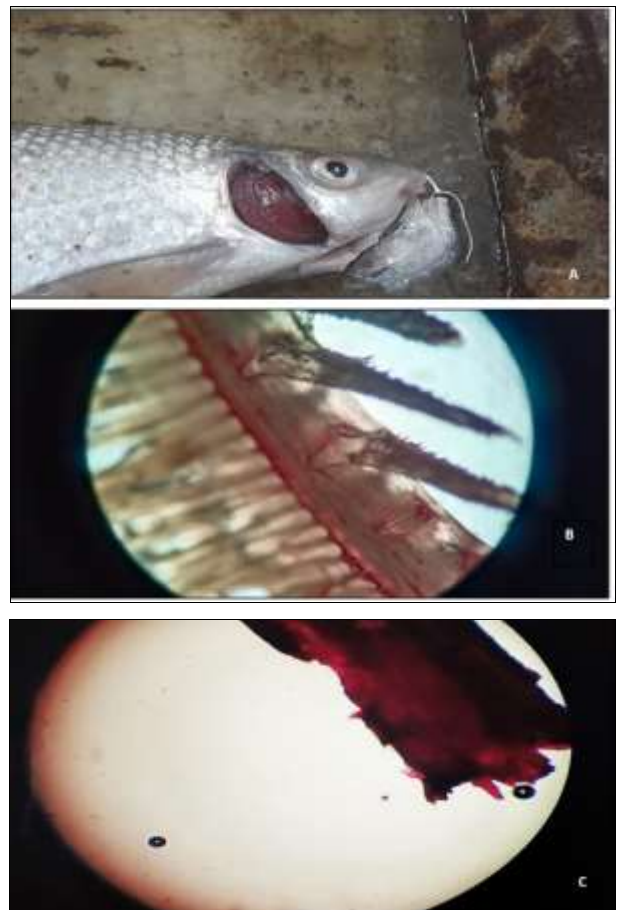


Fig 3: A- In situ image of gills of *Labeo rohita*, B- Microscopic 4x view of gill raker of *Labeo rohita*, C- Microscopic view of gill raker of *Labeo rohita*

In *Catla catla* gill rakers are long, thin and fine structure projected out from the branchial arch but the prominent secondary numerous spines come out from the raker.



Fig 4: A- *In situ* image of gills of *Catla catla*, B- Microscopic view of gill racker of *Catla catla*, C- Microscopic 4x view of gill racker of *Catla catla*

In case of *Cirrhinus mrigala*, gill rakers are positioned on pharyngeal side of gill arch. Their study shows gill rakers are broad at the base and a tapering side at the apex region. In the study hook like rackers are also found. These are small teeth like projections. Gill rakers are generally small here having filliform structure. These structures are responsible for the prevention of entry of any particle except water.

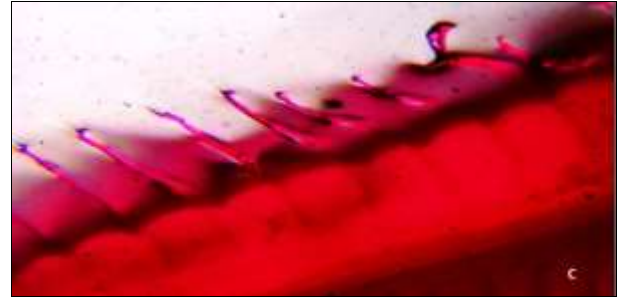


Fig 5: A- *In situ* image of gills of *Cirrhinus mrigala*, B- Microscopic view of gill racker of *Cirrhinus mrigala*, C- Microscopic 4x view of gill racker of *Cirrhinus mrigala*

In case of *Puntius sarana* gill rackers are easily distinguishable from the gill filament. These are present on two rows, projected from anterior and posterior side of gill arch Here miniature task like gill rackers present. Rackers are found short and slightly curved at the tip.



Fig 6: A- *In situ* image of gills of *Puntius sarana*, B- Microscopic view of gill racker of *Puntius sarana*, C- Microscopic 4x view of gill racker of *Puntius sarana*

In *Hypophthalmichthys molitrix* gill rackers are modified for feeding purpose. Here gill rackers are large in size and thick brushlike structure. It is sometimes seeming like gill like filament as it is too much extended and looks similar to gill filament sometimes. Gill rackers are present straightly on the inner margin of the gill arch. Scientists Chapman *et al.*, 2005 showed the bifurcation of gill rackers on gill arch of *Hypophthalmichthys molitrix*.



Fig 7: A- *In situ* image of gills of *Hypopthalmichthys molitrix*, B- Microscopic view of gill racker of *Hypopthalmichthys molitrix*, C- Microscopic 4x view of gill racker of *Hypopthalmichthys molitrix*

In our study we found long, thin hair like filamentous gill rakers in *Mystus sp.* Each gill rakers contain minute secondary amulation. It is upwardly curved. Both gill rakers run parallel for certain distance, then crisscross each other.



Fig 8: A- *In situ* image of gills of *Mystus sp.*, B- Microscopic view of gill racker of *Mystus sp.*, C- Microscopic 4x view of gill racker of *Mystus sp.*

In our study we have found a very tiny gill racker in *Glossglobius giuris*. It is very small and toothlike structure. Bundle of sharp gill rackers found. These teeth like gill rackers helps in grinding food particles.

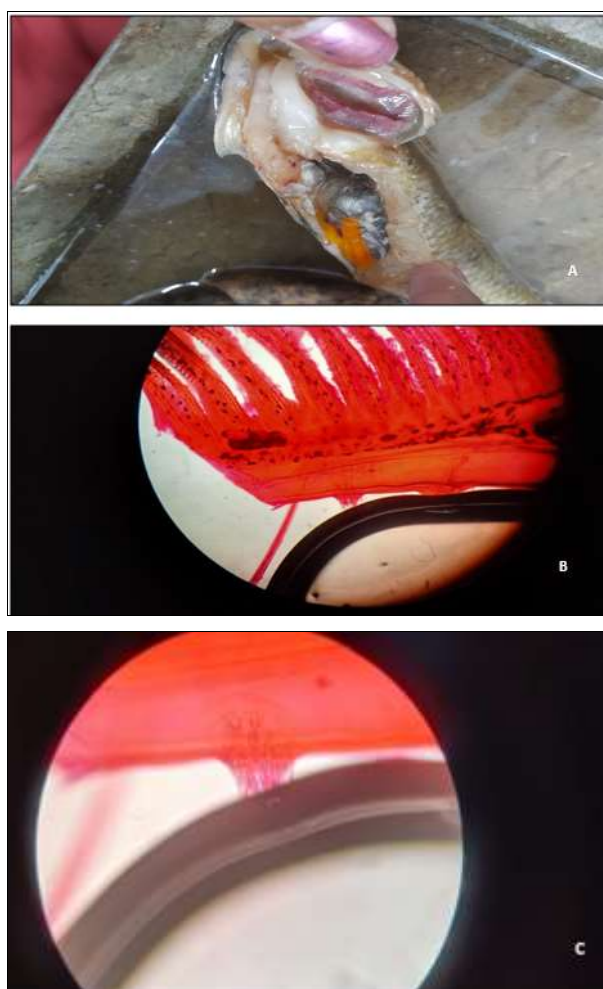


Fig 9: A- *In situ* image of gills of *Glossglobius giuris*, B- Microscopic view of gill racker of *Glossglobius giuris*, C- Microscopic 4x view of gill racker of *Glossglobius giuris*

In *Channa sp.* it is observed that gill rakers are very small and hard and pointed too. Teeth like projections come out from the gill rackers. These help to prevent escape of large prey.



Fig 10: A- *In situ* image of gills of *Channa sp.*, B- Microscopic view of gill racker of *Channa sp.*, C- Microscopic 4x view of gill racker of *Channa sp.*

In *Notopterus notopterus* gill rakers are large in size with broad base. It is villi like structure with blunt end, aligned on the gill arch. Tip of each racker is rounded and smooth also.



Fig 11: A- *In situ* image of gills of *Notopterus notopterus*, B- Microscopic view of gill racker of *Notopterus notopterus*, C- Microscopic 4x view of gill racker of *Notopterus notopterus*.

In *Harpodon nehereus* (Bombay Duck) gill rakers appeared at a cylindrical elevation with spines in their top. A gradual decrease in the gill rakers is also seen from middle to the sides. The spines are conical in shape with pointed curved or straight ends. The length of the gill racker was 300 μ m.



Fig 12: A- *In situ* image of gills of *Harpodon nehereus*, B- Microscopic 4x view of gill racker of *Harpodon nehereus*

In *Pampus argentus* (Pomfret) the gill arch is strong muscular arch. There is a presence of a muscular pit in the gill arch. From the gill arch, epithelial protrusion arises. From the epithelial protrusion the gill filaments arise.



Fig 13: A- *In situ* image of gills of *Pampus argentus*, B- Microscopic 4x view of gill racker of *Pampus argentus*

In *Lates calcarifer* (Bhetki) the gill filaments extend from the bony gill arches in one side. The gill rakers on the either side of the gill arch is petal shaped. The gill rakers are of similar size. The length of the gill raker measured was 300 μm .



Fig 14: A- *In situ* image of gills of *Lates calcarifer*, B- Microscopic 4x view of gill raker of *Lates calcarifer*

In *Polynemus paradiseus* (Topse) there consists of a bony gill arch. The gill arch is composed of layers of bony structure stacked upon one another from where the gill filaments rise. The gill filaments develop from bony gill arches from bony gill arches in one side and there are presence of long dumbbell shaped gill rakers on another side. Serially one structure of gill raker is large and another structure is short and stumpy. The length of gill raker measured was 150 μm .

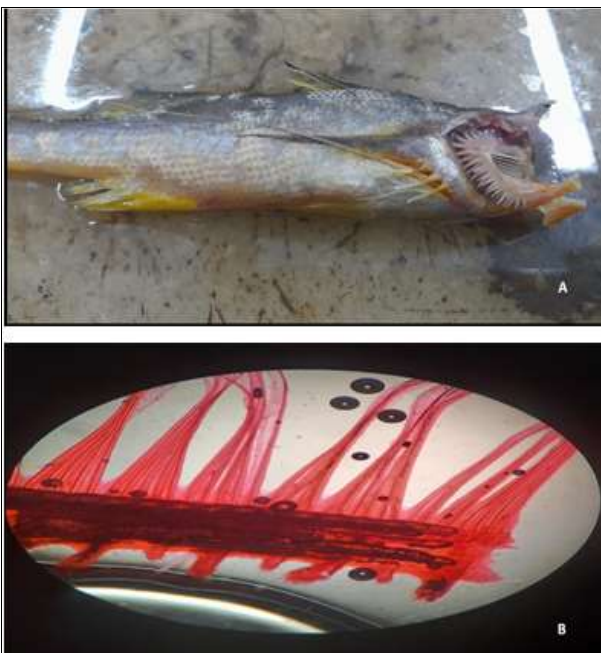


Fig 15: A- *In situ* image of gills of *Polynemus paradiseus*, B- Microscopic 4x view of gill raker of *Polynemus paradiseus*

In *Coilia dussumieri* the gill arch is a bony structure. From the gill arch gill filaments emerge those secondary projections emerging out from them. The length of the gill raker measured was 400 μm .



Fig 16: A- *In situ* image of gills of *Coilia dussumieri*, B- Microscopic 4x view of gill raker of *Coilia dussumieri*

In *Sardinella longiceps* the gill rakers are large in size. They are large spiny pointed extensions protruding from the gill arch. These extensions bent in one direction and their size varies, that is they are smaller near the ends but become larger in the middle areas. The gill arch has a V structure. Each gill arch consists of two limbs (Upper limb and lower limb). The length of the gill raker is 900 μm . Similar observations were found in the *Herklotsichthys quadrimaculatus* (Mousa *et al.*, 2016) [8].

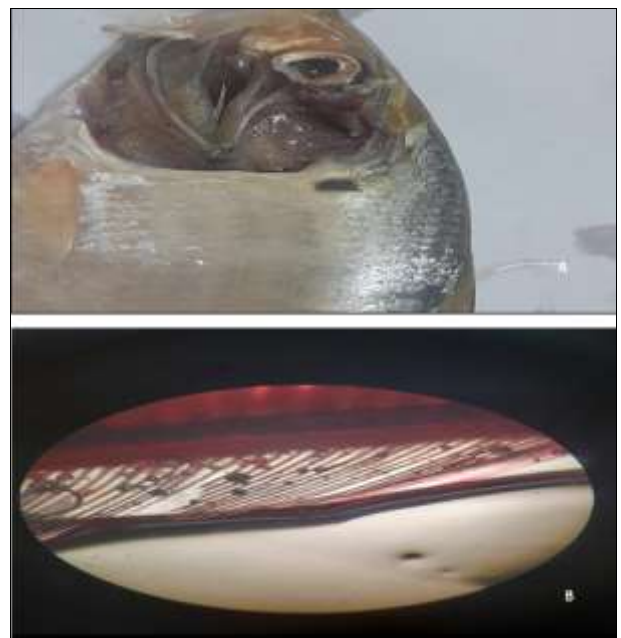


Fig 17: A- *In situ* image of gills of *Sardinella longiceps*, B- Microscopic 4x view of gill raker of *Sardinella longiceps*

Length of gill rakers

The length of the gill raker was measured by the process of micrometry. Micrometry process is used to measure microorganisms.

Sl. No	Name of the fish	Fish type	Length of the gill racker
1	<i>Labeo rohita</i>	Fresh water herbivore	650 μm
2	<i>Catla catla</i>	Fresh water herbivore	300 μm
3	<i>Cirrinhus mrigala</i>	Fresh water herbivore	170 μm
4	<i>Puntius sarana</i>	Fresh water herbivore	170 μm
5	<i>Hypophthalmichthys molitrix</i>	Fresh water herbivore	950 μm
6	<i>Mystus sp.</i>	Fresh water carnivore	300 μm
7	<i>Glossogobius giuris</i>	Fresh water carnivore	500 μm
8	<i>Channa sp.</i>	Fresh water carnivore	Not Known
9	<i>Notopterus notopterus</i>	Fresh water carnivore	200 μm
10	<i>Harpodon nehereus</i>	Marine water carnivore	300 μm
11	<i>Pampus argentatus</i>	Marine water carnivore	No significant amount of gill racker seen
12	<i>Lates calcarifer</i>	Marine water carnivore	300 μm
13	<i>Polynemus paradiseus</i>	Marine water carnivore	150 μm
14	<i>Coilia dussumieri</i>	Marine water carnivore	400 μm
15	<i>Sardinella longiceps</i>	Marine water herbivore	900 μm

Conclusion

The feeding habit of fish depends on the structure of gill rakers. The morphological characters of gill rakers have demonstrated unique structural specifications that are various in the feeding behavior of fishes. As per our study, the gill rakers of herbivorous marine fish *Sardinella longiceps* were large in size. They were large spiny extension protruding from the gill arch. The gill rakers were long and slender. It is specialized for the processing and consuming material such as algae and sea grass. The gill has a dual function, that they change the direction of water as a first step and secondly, they filter the food particles (Sanderson *et al.*, 1996) ^[9]. In carnivorous fishes, it was seen that gill rakers were short in size and less in number with wide spaces between them. The gill rakers were spiny and conical or triangle or triangle shaper with pointed curves as seen *Harpodon nehereus*. In *Lates calcarifer*, the gill racker was petal shaped but they too had small spiny projections projecting out from the gill rakers. In *Polynemus paradiseus* the gill rakers were dumbbell or club shaped and placed serially. They were irregular in shape and short and stumpy structure and one large. The minute spines on the gill racker prevent the escape of slippery, slimy and smooth prey (Abudiazah 1995, Alsafy 2013) ^[1,3]. However, it was seen in *Pampus argentatus* being so carnivorous no significant amount of gill racker was seen and hence how the feeding of *Pampus argentatus* using the gill racker is unknown to us. In *Coilia dussumieri* however it was seen that the gill rakers were were spiny, long extensions having secondary projections. *Coilia dussumieri* being a carnivore had the characteristics of an herbivore. From the study we can conclude that *Sardinella longiceps*, *Hypophthalmichthys molitrix* has longest gill racker $\geq 900 \mu\text{m}$ which is Herbivore. This gill racker actually helps to sieve or filtering the phytoplankton. Both marine and freshwater carnivore fishes contain gill rakers from 150- 300 μm . In our study, Lata and Pomfret fish are carnivore have no remarkable structure as they feed directly small fishes.

References

1. Abuzinadah OA. Gill raker morphology in some Red Sea fish of different feeding preferences. Mar Sci. 1995;6(1):1-12.
2. Almeida APG, Behr ER, Baldissotto B. Gill rakers in six teleost species: influence of feeding habit and body size. Ciênc Rural. 2013;43:2208-2214.
3. Alsafy MA. Gill morphology in two Mediterranean Sea fishes of similar feeding preferences: sea bream (*Sparus aurata* L.) and sea bass (*Dicentrarchus labrax*). Vet Res Commun. 2013;37:163-170.

4. Alsafy MA, El-Gendy SA, El-Bakary NE, Kamal BM, Derbalah A, Roshdy K. Morphological comparison of the detailed structure of gill rakers from three different feeding habits of marine fish species. Zoomorphology. 2023;142(1):87-97.
5. Kapoor BG. Gill rakers of a few Indian freshwater fishes. Ann Mus Civ Stor Nat Genova. 1965;75:126-143.
6. Kumari U, Yashpal M, Mittal S, Mittal AK. Surface ultrastructure of gill arches and gill rakers in relation to feeding of an Indian major carp, *Cirrhinus mrigala*. Tissue Cell. 2009;41(5):318-325.
7. Langeland A, Nøst T. Gill raker structure and selective predation on zooplankton by particulate feeding fish. J Fish Biol. 1995;47(4):719-732.
8. Mousa MA, Mousa MA, Azab AM, Khalaf-Allah HM, Mohamed MA. Comparative studies on the gill rakers of some marine fishes with different feeding habits. Int. J Dev. 2016;5(1):91-108.
9. Sanderson SL, Stebar MC, Ackermann KL, Jones SH, Batjakas IE, Kaufman L. Mucus entrapment of particles by a suspension-feeding tilapia (Pisces: Cichlidae). J Exp Biol. 1996;199(8):1743-1756.